Post-embryonic Development of *Oppia nitens* (Acarina: Oribatei)

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Abstract: The present research on the life history of *Oppia nitens* C. L. Koch adds another species of oribatoid mite which has been successfully reared under standard laboratory conditions. For the first time culturing was carried through the F_2 generation. For experimentation employing oribatoid mites as test organisms, particularly in regard to the effects of pesticides and herbicides, a standard reference table of their life histories is necessary. A table of published life histories, given herewith, provides the most comprehensive summary of information available.

The laboratory methods followed those of Sengbusch (1954, 1963). A temperature of 20° C. and a relative humidity of 82% were maintained. Adults were isolated from moist mor humus collected from a coniferous forest floor. The average length of time in days for each of the immature stages of the F_1 generation was: egg—8.5; larva—7.4; protonymph—7.6; deutonymph—9.3; tritonymph—12.3. The duration of the combined developmental stages varied from 39 to 55 days. The quiescent period which precedes each molt lasted approximately 2 to 3 days except the one before the exuviation of the adult which continued 4 to 5 days. The average length of time for the post-embryonic development of the F_2 generation was not different from that of the F_1.

INTRODUCTION

The present research on the life history of *Oppia nitens* C. L. Koch represents another species added to the list of Oribatei which have been successfully cultured under standard conditions of temperature and humidity. For the first time a species of oribatoid mite was reared through the F_2 generation.

Oribatoid mites, although once thought to be harmless plant feeders, are now known to be of economic significance. Sellnick (1928) believed that they play an important role in the economy of nature by contributing to the fertility of the forest soil. Woodring (1963) in a discussion of the value of oribatoids to litter reduction stated, "it seems hard to believe that in view of their habits, nutrition, and vast numbers they would not be important." Jacot (1930), on the other hand, pointed out injurious effects induced by their phytophagous habits. However, it was the work of Stunkard (1937) which gave impetus to research on these relatively little-known animals. It was he who established that the oribatoids may act as the intermediate hosts of certain anoplocephaline cestodes.

MATERIALS AND METHODS

The laboratory methods followed those of Sengbusch (1954, 1958, 1963). While they are somewhat tedious, they have produced approximately one-third of the life histories of oribatoid mites which have been reported (Table 3).

Adults were collected by means of a modified Tullgren funnel (Sengbusch, 1951) from the moist mor humus layer of a coniferous forest floor. They were isolated in separate glass microcells modified from the description given by Jacot (1937) and were observed daily under a binocular dissecting microscope using a magnification of 30×. The microcells consisted of ordinary 3 × 1 inch microslides on which were glued one or two small glass rings. Filter paper was cut to fit snugly in the bottom and moistened to provide the water which is so necessary for this group of mites. A cover was provided by another microslide held in place by a small rubber band. No attempt was made to make this in air-tight seal as these culture cells were then placed in Scheibler desiccators containing a saturated solution of $ZnSO_4$ to provide a relative humidity of 82% (Ludwig and Landsman, 1937). The desiccators were kept in a constant temperature room set at 20° C.

OBSERVATIONS

Like most Acari, the oribatoid mites leave the egg as six-legged larvae and subsequently pass through four molts. After the first molt, they are in the first eight-legged nymphal stage (protonymph), and then pass through two further nymphal stages, the deutonymph and tritonymph.

Each molt is initiated by a quiescent period of various lengths. At its onset the mite fastens its claws (unguiculae) into the filter paper and arches the dorsum. It stays in this position without feeding for two to three days. However, it would be incorrect to refer to this time as a resting period, for internally the mite is undergoing the morphological and physiological changes which will be evidenced in the following stadium. The period is terminated by the splitting of the old exoskeleton (exuvium) and the emergence of the next stage.

All stages nourish themselves in a similar fashion and also carry on the same modes of life. *Protococcus*, a green alga found on bark, was used throughout the investigation as food for the immature and adult *Oppia nitens*.

Ontogeny occurs by a gradual development from the egg to the sexually mature adult. The female mite, attempting to hide the eggs, may insert the long ovipositor into clumps of *Protococcus* or into the crevice between the edge of the filter paper and the glass and extrude the eggs. The eggs are typically oval to ovate and have one side flattened as do many insect eggs. Eggs recently laid have a whitish, almost translucent appearance and are relatively easy to locate in the small culture cells. Within three to four days development becomes evident externally as an amber pigmentation becames visible at both poles. The thin shell is almost transparent and slightly plastic so that major variations in form and color are noticeable with low magnification. A day or two before hatching, the outline of the larva can easily be perceived using a magnification of 60×. Just before emergence, the exoskeleton of the larva becomes totally pigmented with the amber color noted above.

Table 1. Length of time in days of developmental stages of *Oppia nitens* (F_1) at 20° C.

Emergence of larva	Emergence of proto.	Emergence of deuto.	Emergence of trito.	Emergence of adult	Total
9	7	7	8	11	42
10	7	7	9	14	47
10	7	8	5	9	39
7	9	7	13	11	47
8	8	7	18	14	55
8	8	7	11	18	52
11	7	8	7	6	39
6	7	8	9	10	40
8	10	6	6	10	40
6	7	11	7	11	42
10	5	7	9	21	52
Av. 8.5	Av. 7.4	Av. 7.6	Av. 9.3	Av.12.3	Av.45.0

From Table 1 it is evident that there is some variation in the duration of the stadia in this species. From egg to adult 39 to 55 days were required in the eleven specimens that reached maturity. A predominance of the seven and eight days required for the emergence of the protonymph and deutonymph is noticeable. It seems probable that with a large enough sampling and with the environmental conditions approaching optima, the average times would be relatively constant. The greater length of time necessary before the emergence of the adult is due to the greater morphological changes necessary before the final molt.

The F_1 females began oviposition approximately three months after emergence. Because the experiment had to be terminated, only six specimens attained adulthood. From Table 2 agreement can be seen between the total development time in the F_2 generation (46.0 days) and that of the F_1 (45.0 days). No statistical difference exists in the duration of post-embryonic development in the two generations, which supports the prediction that the method of Sengbusch (1954) can be used to culture any oribatoid mite.

We saw no spermatophores in any of the culture cells containing adults. Spermatophores have been described from several species of oribatoids (Seng-

Table 2. Length of time in days of developmental stages of *Oppia nitens* (F_2) at 20° C.

Emergence of larva	Emergence of proto.	Emergence of deuto.	Emergence of trito.	Emergence of adult	Total
8	6	7	10	12	43
9	5	10	13	7	44
9	6	6	11	11	43
7	6	8	4	21	46
7	7	7	8	21	50
9	5	7	11	18	50
Av. 8.2	Av. 5.8	Av. 7.5	Av. 9.5	Av.15.0	Av.46.0

Table 3. Length of time in days of developmental stages of oribatoid mites.

		Emergence of larva	Emergence of protonymph	Emergence of deutonymph	Emergence of tritonymph	Emergence of adult	Total
Hypochthonius rufulus Koch	Sengbusch (1958)	30.0	21.8	19.1	21.5	24.5	122.0
Steganacarus diaphanus Jacot	Hartenstein (1962f)						150
Nanhermannia nana (Nicolet)	Sengbusch (1958)	13.2	20.4	24.1	22.5	31.4	111.3
Hermannia scabra (Koch)	Jalil (1965)	15	16	41	42	70	184
Nothrus silvestris Nicolet	Sengbusch (1958)	15.8	32.9	37.3	28.3	40.0	152.5
Camisia spinifer (Koch)	Sengbusch (1958)	6.7	18.2	26.9	29.1	50.8	125.6
Camisia segnis (Hermann)	Grandjean (1950)						200
Platynothrus peltifer (Koch)	Grandjean (1950)			36			150
Platynothrus peltifer (Koch)	Hartenstein (1962d)		35	27	31	24	117
Platynothrus peltifer (Koch)	Block (1965)						330–360
Trhypochthonius tectorum (Berlese)	Taberly (1952)	11–35	15–20	13–27	15–32	18–50	72–164
Dameus clavipes (Hermann)	Pauly (1956)						75
Dameus clavipes (Hermann)	Sengbusch (1958)	5.1	12.3	12.1	14.5	20.0	64.0
Dameus clavipes (Hermann)	Block (1965)						330–360
Dameus onustus Koch	Pauly (1956)						150
Dameus onustus Koch	Sengbusch (1958)	8.7	28.3	26.7	29.3	40.0	130.3
Dameus onustus Koch	Bhattachyryya (1962)	17.4	58.0	40.0			
Dameus auritus Koch	Pauly (1956)						75
Dameus boreus Bulanova-Zakhvatkina	Sitnikova (1959)	20	19	22	25	30	120
Belba kingi Hartenstein	Hartenstein (1962a)	14±2	15±3	9±2	17±1	9–18	63–76
Metabelba montana (Kulczynski)	Hartenstein (1962b)						65
Cepheus palmicinctum (Nicolet)	Michael (1888)	4	53	40	78	200	375
Eremobelba nervosa Hartenstein	Hartenstein (1962b)	15	10–15	15–18	14–16	11–15	68–75
Ceratoppia bipilis (Hermann)	Michael (1888)						79
Ceratoppia bipilis (Hermann)	Taberly (1957)	3–5	14–24	9–13	9–13	14–31	49–87
Tectocepheus velatus (Michael)	Murphy & Jalil (1964)	13	24	25	28	46	102

TABLE 3. (*Continued*)

		Emergence of larva	Emergence of protonymph	Emergence of deutonymph	Emergence of tritonymph	Emergence of adult	Total
Oppia nitens Koch	Michael (1888)						40(–)
Oppia nitens Koch	Sengbusch & Sengbusch (1970)	8.5	7.4	7.6	9.3	12.3	45.0
Oppia nova (Oudemans)	Woodring & Cook (1962)						23
Minunthozetes semirufus (Koch)	Sengbusch (1958)	6.1	6.8	7.0	7.1	11.2	38.0
Ceratozetes gracilis (Michael)	Haarløv (1960)						41
Ceratozetes gracilis (Michael)	Hartenstein (1962c)	32	20	36	28	19	119–149
Ceratozetes cisalpinus Berlese	Woodring & Cook (1962)						32
Ceratozetes jeweli Rockett & Woodring	Rockett & Woodring (1966)	12	11	9	9	12	53
Galumna elimatus var. (Koch)	Sengbusch (1954)	14.9	16.1	15.6	15.9	24.8	87.3
Galumna nervosus (Berlese)	Sengbusch (1954)	10.7	8.3	7.9	8.5	11.7	47.1
Galumna nervosus (Berlese)	Sengbusch (1958)	8.8	7.5	7.6	7.3	12.0	43.1
Pergalumna omniphagous Rockett & Woodring	Rockett & Woodring (1966)	11	7	7	7	10	42
Galumna confusa Woodring	Woodring (1965)	7–14	5–8	7–13	11–15	12–17	46–50
Galumna longipluma (Berlese)	Sengbusch (1954)	10.8	10.8	11.5	12.6	15.3	60.9
Acrogalumna longiplumus (Berlese)	Sengbusch (1958)	11.8	13.4	12.9	13.6	17.2	65.8
Galumna parva Woodring	Woodring (1965)	7–8	4–10	7–9	9–11	9–13	33–41
Rostrozetes flavus Woodring	Woodring (1965)	8–9	6–9	8–10	9–13	10–14	35–45
Scheloribates laevigatus (Koch)	Cleat (1952)						42–115 av. 61
Scheloribates laevigatus (Koch)	Woodring & Cook (1962)						64
Scheloribates parabilis Woodring	Woodring (1965)	8–11	3–6	3–7	3–8	3–8	14–24
Scheloribates nudus Woodring	Woodring (1965)	8–11	3–6	3–7	3–7	3–8	28
Protoribates lophotrichus (Berlese)	Hartenstein (1962e)	23	23	27+	32+	23+	150
Euphthiracarus sp.	Rhode (1955)						64

busch, 1961), but there is also evidence that parthenogenesis occurs in some species (Grandjean, 1947; Sengbusch, 1958). *Oppia nitens* probably falls into the latter category.

DISCUSSION

The present research is the first consideration of the life cycle of *Oppia nitens* C. L. Koch since Michael's original work in the late 1800s. Michael reported only the total longevity utilizing crude culturing techniques. The current study lists the duration in days of each immature stage plus the total egg to imago period. These latter figures are more realistic than Michael's because they were obtained under standard laboratory conditions.

For the first time, data are presented from the development of an F_2 generation. Previous workers have generally assumed a lack of distinction between the progeny of parents obtained from nature and the offspring of laboratory raised mites. We were able to demonstrate the similarity of development times between the two groups in this species. Our culturing conditions do not appear to change the duration of the stadia or the total elapsed time for the life-cycle of *Oppia nitens*. Although the earlier assumption was found to be correct, the specific results obtained by experimentation reduce the variables involved in the use of these mites as test organisms.

The forty-nine life histories which have been published, beginning with the initial investigations of Michael in 1884, and continuing to contemporary studies are listed in Table 3. There is wide latitude in the reported times, plus the frequent lack of data for the individual immature stages. A comparison of similar species reveals discrepancies which probably reflect differences in culturing techniques. According to Woodring (1963), ". . . oribatoids have been reared by several . . . but they have been cultured only by Sengbusch (1954), and Woodring and Cook (1962)." For experimentation employing oribatoid mites as test organisms a standard reference table of their life histories is necessary. Table 3 provides the most comprehensive summary of information available.

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